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SCENIC BEAUTY ASSESSMENT AND MODELING OF LARGE
AREAS USING FOREST SURVEY DATA

Terry C. Daniel

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by
Terry C. Daniel

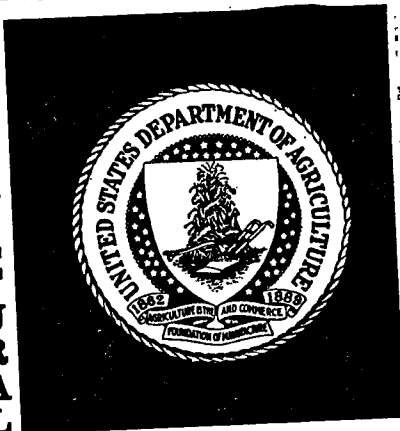
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Scenic Beauty Assessment and Modeling of Large Areas
Using Forest Survey Data

Final Report

Cooperative Research Agreement No. 28-CA-344
University of Arizona
and
Rocky Mountain Forest and Range Experiment Station
USDA Forest Service
31 January 1989

Submitted by:

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Psychology and Renewable Natural Resources
University of Arizona

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Summary of Analyses for the 1985 FIACO Study

This report briefly summarizes research relating 1984 FIA physical data from the western slopes of Colorado to perceptual data collected at the University of Arizona in 1985. Color slides taken at the time the physical data were collected were shown to U. of Arizona students, who rated them for scenic beauty. Slides from both forest and woodland areas were shown in a number of different representational contexts, ranging from an individual slide to a group of 8 slides used to depict a plot (see Figure 1 & Table 1 below). High correlations among ratings for the same areas represented by different groupings of slides indicates that a contextual manipulation of this sort does not substantially affect ratings.

PHOTO SAMPLE REPRESENTATIONS

Forest Plots. Twenty color slides were taken at 5 different points within each plot. Figure 1 shows the location and direction in which slides were taken at each plot. Table 1 lists the representation methods used, and the number of plots represented with each method, with one exception. Point Representation A shows a plot as being represented by five groups (points) of four slides each. In fact, some plots were only represented by three or four points for this representation method. This occurred because some slides were missing, and others were improperly exposed and/or focused. Only those points that had four good slides were used, and only those plots that could be represented by at least three points were used.

Missing or poorly shot slides also reduced the number of common plots among representations to 19. Raw scores and SEE's for these 19 plots were correlated across representation methods, and those matrices are presented in Table 2. Raw score intercorrelations ranged from $r=.85$ to $r=.91$, and SEE intercorrelations ranged from $r=.80$ to $r=.91$. These high correlations among representation methods suggests that this manipulation had little or no effect on ratings.

Woodland Plots. As Table 1 indicates, only four slides were taken at each woodland plot. Consequently, only two representation methods were used. Raw scores and SEE's were obtained for 60 plots, and the corresponding correlations between representation methods were quite high: Raw score $r=.94$; SEE $r=.87$.

REGRESSION MODELING

The physical and perceptual data for the forest areas were also subjected to regression analysis, in an attempt to model scenic beauty ratings.

Forest Plots. In a series of stepwise regressions, measures of the physical attributes of the forest plots proved to be of limited utility

when regressed onto SB ratings. Apart from non-managed, categorical physical variables (e.g., habitat, landuse), five variables were associated with SB in the initial regression analysis: 16"-20" ponderosa pine (PP); herbage canopy (HC) of trees in the lowest tier; 5"-9" juniper (JU); HC of shrubs in the highest tier; and 5"-9" PP. Each of these variables was negatively correlated with SB, with 16"-20" PP accounting for 20% of the variance in SB ratings, while the remaining variables combined to account for another 30% of the variance.

A second regression was run using just tree variables (species by size class) and herbage variables (HC of grass, forbs, shrubs and trees in three tiers) as predictors. In this instance, 16"-20"PP was the only variable to enter the equation, again accounting for 20% of the variance in SB ratings.

At this point, factor analysis was used to group the tree and herbage variables into some meaningful categories, so that a smaller group of more powerful predictor variables could be used in the regression analysis. The factor analysis yielded the following "combination" variables:

small aspen = aspen seedlings + aspen saplings
 large aspen = 9"-12"asp + 12"-16"asp + 16"-20"asp
 small cottonwood = cottonwood saplings + 5"-9"cot
 large cottonwood = 20"-24"cot + 24+"cot
 juniper = 5"-9"jun + 9"-12"jun
 medium ponderosa pine = 5"-9"pp + 9"-12"pp + 12"-16"pp
 large ponderosa pine = 16"-20"pp + 20"-24"pp + 24+"pp
 grass = HCGR lowest tier + HCGR middle tier
 forbs = HCFO lowest tier + HCFO middle tier
 shrubs = HCSH lowest tier + HCSH middle tier + HCSH highest tier

When these variables were used in a regression analysis, the only variable to enter the equation was large ponderosa pine, which was negatively associated with SB ratings, and accounted for 21% of the variance. This reflects the preceding analyses, where 16"-20"PP was negatively associated with SB ratings and accounted for 20% of the variance.

In addition to the above analyses, SB ratings for 13 of the 19 forest plots (six plots were dropped from this analysis because they had no PP trees) were correlated with predicted SB ratings generated by the following regression model:

<u>Variable</u>	<u>Regr Coeff</u>
Herbage canopy (%)	.915
Herbage height (inches)	1.602
5"-12"PP	-.044
24+"PP	1.333
Constant	-13.116

Values for these variables were found at the point and plot level for each of the 13 plots, which involved estimates for both of the herbage variables, because they were not available in the form specified by the

model. The plot-level correlation (13 cases) for predicted and obtained SB ratings was $r=.39$, while the point-level correlation was $r=.20$. Among the welter of possible explanations for these low correlations, the following seem most promising: First, the regression model used was developed in a different PP forest area, and it is possible that it does not generalize well to new forest areas; Second, the 13 plots used to generate the obtained data do not constitute a PP forest exemplar, and thus the model was inappropriately applied; Third, the values for both of the herbage variables had to be estimated, resulting in less precise predictions; Fourth, the most important variable in this data set (in terms of variance accounted for in the above regression equations), 16"-20"PP, was not represented in the prediction regression model; and finally, it is possible that these variables are not linearly related to SB ratings in this data set.

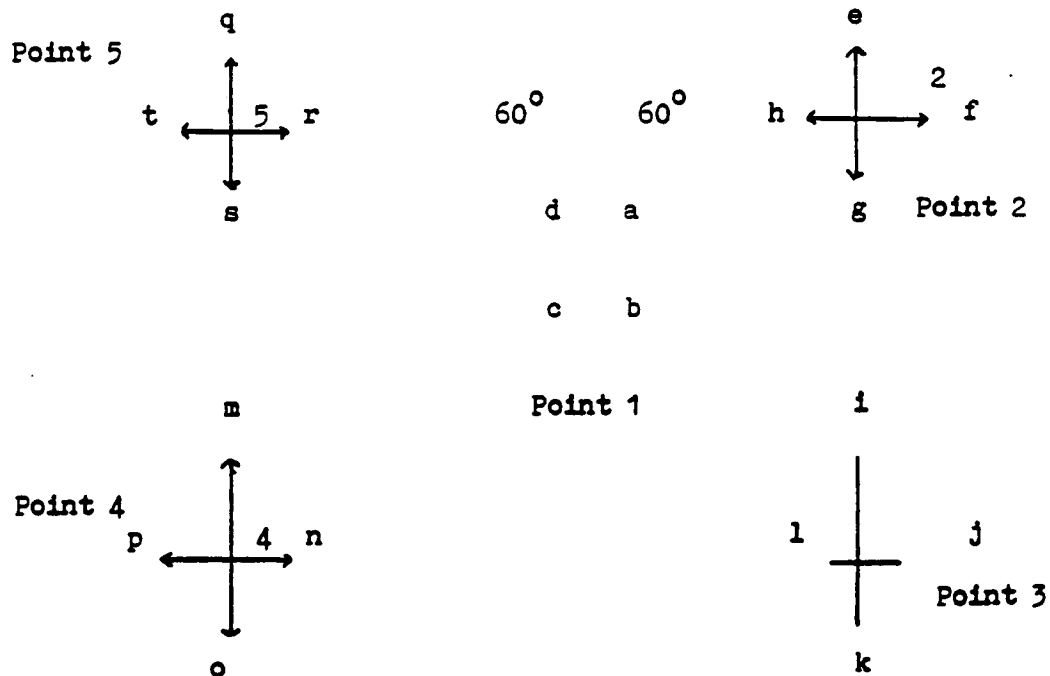
Woodland Plots. Comparison of SBEs for individual scenes with the SBEs of the corresponding plots indicated wide variation in scenic beauty among the scenes at a plot. This variability was due mainly to the change in perspective from one scene to the next. The plots tended to be in sparsely vegetated areas on moderate to steep slopes, so that some scenes looked out over wide valleys while others looked into a hill side. The onsite vegetative inventory measured only the near-by vegetation, which because of the sparseness of the vegetation, left much of the vegetation in the scenes out of the data used to describe the characteristics of the scenes.

Because of these depth of view problems, modeling of woodland plot scenic beauty with these data was not pursued. In essence, the woodland plots required a combination of near-view and vista modeling. Unfortunately, vista modeling was not within the scope of this project. Future scenic beauty efforts should carefully assess the depth of view issue early in the stage of the research.

Table 1				
Photo Representation Methods to be Compared				
Method	# slides/ Judgment	Slides to be Shown for Each Sample Plot *	# Plots Represented	
<u>FOREST PLOTS</u>				
Full Plot Representation	8	A [a,b,c,d,g,l,m,r] and B [a,b,c,d,h,s,n,i]	30	F8A F8B
Point Representation A	4	[abcd], [efgh], [ijkl], [mnop], [qrst]	30	F4A
Point Representation B	4	[abcd], [g,l,m,r]	30	F4B
Individual Slide Representation	1	[a], [b], [c], [d]	30	F1R
<u>WOODLAND PLOTS</u>				
Full Point/ Plot Representation	4	[a,b,c,d]	60	
Individual Slide Representation	1	[a], [b], [c], [d]	30	

* Refer to Figure 1 for slide identification. The [] indicate which slides will be shown together in sequence for a single overall scenic beauty judgment.

Sample Plot XXX:



o Represents an inventory point

↑ Represents direction of camera aim

Lower case letters indicate order of photo sample, from a to t.

Figure 1. Photo Sample Location and Orientations for Forest sample plots.

Table 2 - Correlation coefficients for ratings from different slide representations.

A. Raw Scores

	F8AR	F8BR	F4BR	EIR	F4AR
F8AR	1.0000 (19) P= .001	.8476 (19) P= .001	.8628 (19) P= .001	.8546 (19) P= .001	.8856 (19) P= .001
F8BR	.8476 (19) P= .001	1.0000 (19) P= .001	.8663 (19) P= .001	.8775 (19) P= .001	.8864 (19) P= .001
F4BR	.8628 (19) P= .001	.8663 (19) P= .001	1.0000 (19) P= .001	.9147 (19) P= .001	.8446 (19) P= .001
FIR	.8546 (19) P= .001	.8775 (19) P= .001	.9147 (19) P= .001	1.0000 (19) P= .001	.8711 (19) P= .001
F4AR	.8856 (19) P= .001	.8864 (19) P= .001	.8446 (19) P= .001	.8711 (19) P= .001	1.0000 (19) P= .001

(COEFFICIENT / CASES / SIGNIFICANCE) (99.0000 MEANS UNCOMPUTABLE)

B. SBEs

	F8AS	F8BS	F4BS	FIS	F4AS
F8AS	1.0000 (19) P= .001	.7995 (19) P= .001	.8301 (19) P= .001	.8176 (19) P= .001	.8546 (19) P= .001
F8BS	.7995 (19) P= .001	1.0000 (19) P= .001	.8688 (19) P= .001	.8730 (19) P= .001	.8898 (19) P= .001
F4BS	.8301 (19) P= .001	.8688 (19) P= .001	1.0000 (19) P= .001	.9167 (19) P= .001	.8510 (19) P= .001
FIS	.8176 (19) P= .001	.8730 (19) P= .001	.9167 (19) P= .001	1.0000 (19) P= .001	.8733 (19) P= .001
F4AS	.8546 (19) P= .001	.8898 (19) P= .001	.8510 (19) P= .001	.8733 (19) P= .001	1.0000 (19) P= .001

(COEFFICIENT / CASES / SIGNIFICANCE) (99.0000 MEANS UNCOMPUTABLE)

Appendix A: Study Plan

SCENIC BEAUTY ASSESSMENT AND MODELING OF LARGE AREAS USING FOREST SURVEY DATA

Research studies applying psychophysical methods of assessing near-view scenic beauty for the ponderosa pine type in the Southwest have been very successful (e.g., Schroeder and Daniel, Forest Science 1981; Schroeder and Brown, J. Leisure Research 1983; Brown and Daniel RM Research Paper, 1984). There are also indications that the method works well in Southeastern pine and hardwoods (Buhyoff and Associates, Forest Science 1982, in press). These studies have developed models expressing relative scenic beauty as a function of physical site characteristics, allowing managers to assess the scenic beauty of areas similar to the research study areas as well as to predict the scenic effects of alternative treatments.

There is considerable interest in extending this method to other vegetation types and to large geographic areas. Proposed applications of such extensions vary from project planning to the RPA Assessment. However, the detailed physical field data which is required for applying the psychophysical approach is very costly to obtain. This is in contrast to the scenic data (the color slides, which are shown to observers to obtain scenic beauty estimates) taken at each inventory site which are relatively inexpensive. Furthermore, the added cost, to an existing biophysical inventory, of taking the necessary color slides is very small.

The forest survey units located at several Forest Service Experiment Stations annually take data very similar to that which

has been used to model scenic beauty in the research studies cited above. And the survey units sample all forest types at systematic grid locations. This study will investigate the opportunity for extending Forest Survey to include scenic beauty assessment. The specific objectives of the study are to:

1. Obtain SBEs based on scenic beauty judgments of the Colorado Western Slope slides, using slide presentation context(s) and set(s) of baseline slides appropriate for the assessment and modeling of the large study areas.
2. Compare the reliability of SBEs obtained for the study area with the reliability of SBEs obtained for Arizona ponderosa pine (a more homogenous area).
3. Develop models expressing SBE as a function of physical data collected by the Forest Survey Unit.
4. Compare the models with those developed in other scenic beauty modeling efforts.
5. Investigate the impact of mid-range and distant elements in the slides of SBEs and modeling success, and examine ways to account for mid-range and distant scenic elements in modeling.
6. Suggest guidelines for scenic beauty assessment and modeling using Forest Survey data, to include required (a) sample size, (b) photographic density per sample location, and (d) slide presentation context breakdowns.

This study is a test of using forest survey data to assess

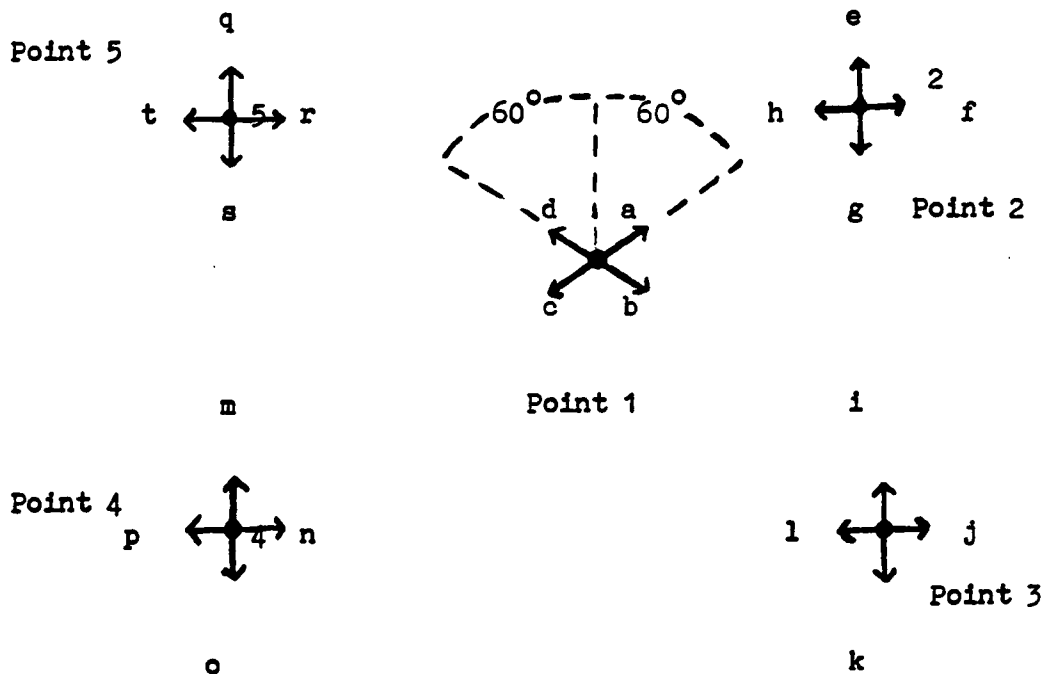
and model the scenic beauty of forest vegetation of the western slope of Colorado. Slides taken and physical data collected at timber and woodland sites by the Forest Survey Unit of the Intermountain Forest and Range Experiment Station will be used. The slides will be shown to student volunteers at the University of Arizona, and SBEs will be obtained for each slide. The SBEs will be related to the field survey measurements to develop scenic beauty models.

The basic photographic and scenic beauty estimation methodology is essentially as described by Daniel and Boster (1976, Research Paper RM-167), as amended by specific instructions to adapt to Survey Unit procedures. Modeling methodology is described by Schroeder and Daniel (1981) and Brown and Daniel (1984). In addition, standard parametric techniques for statistical inference will be utilized. The physical inventory methodology is generally described in the Forest Survey Field procedures manual, with appendices, of the Intermountain Station. A more detailed description of experimental procedures is presented below.

Photo Survey Procedure. Specific photographic equipment and procedures are presented in the attached Appendix A. In general the procedure is to collect 4 color slide photos oriented at 90° to each other at each inventory point within each survey plot. Figure 1 presents the photo orientation layout for Forest plots, where 5 inventory points are distributed within each plot. Woodland plots have only one inventory point, and only 4 photos are taken at 90° intervals from that point. After processing,

Sample Plot XXX:

1N



● Represents an inventory point

→ Represents direction of camera aim

Lower case letters indicate order of photo sample, from a to t.

Figure 1. Photo Sample Location and Orientations for Forest sample plots.

all color slides are individually labeled to identify sample plot, sample point, and orientation.

SBE Analysis. Slides will be shown to student volunteer observer groups ($N \sim 15$) to obtain a minimum of 30 observations per sample photo, point, or plot, depending upon the method of site representation chosen. Observers will evaluate either Forest or Woodland plots, but the two sample plot types will not be mixed together for these initial assessments. Previous research (e.g., Brown & Daniel, 1984; Schroeder & Daniel, 1980) indicates that three basic approaches are possible for obtaining SBEs in the present context: 1) individual slides from all plots may be judged independently and the individual SBEs for all slides from a plot (or point) averaged to obtain an overall SBE for that plot (or point); 2) the 4 slides for a point may be shown together and the observer required to give an overall judgment for that point; or (3) all, or some subset, of the 20 slides for each plot may be shown together and the observer required to give an overall judgment for the entire sample plot. Of course, in the case of Woodland plots, there will only be 4 photos available for each plot, so the second and third approaches would reduce to one.

Each of the above methods for obtaining plot level SBEs will be used and compared. Ideally, there would be close correspondence in the values provided by each approach. Approaches may vary, however, in terms of internal reliability and sensitivity. Which provides the most valid measure viz. actual on-site evaluations will not be addressed in the present

study.

Table 1 displays the sample plot photo representation methods that will be tested and compared (objectives 1 and 2). In every case, the final SBE metric will be a single value for each sample plot. The reliability of each method will be assessed by intra- and inter-class correlation coefficients, and sensitivity will be measured in terms of the ratio of within plot and between plot variance in an ANOVA, employing either observers, slides, or points as replicates as is appropriate to the method. Relationships among methods will be investigated by correlation/regression analysis and by visual inspection of scatter plots. Selection of the "best" method for obtaining plot-level SBEs will be based on the above criterion, as well as the investigators' judgments of the efficiency (time and observers) and the "face validity" of each approach. All sample plots will be assessed using the selected method.

Scenic Beauty Models. SBEs obtained for each sample plot will be used as dependent values in a multiple regression analysis with the forest inventory bio/physical values for the plots serving as independent values (Objective 3). Alternative models will be developed and compared in terms of the variables included, their relative weights (B coefficients) and the statistical properties of the resultant models (e.g., R^2 , standard error, and significance). Models will also be compared to models previously developed in other studies (e.g., Brown & Daniel, 1984; Schroeder & Daniel, 1981) to meet Objective 4.

Analysis of Vista Elements. Many of the Forest plots, and

Table 1

<u>Method</u>	<u># slides/ Judgment</u>	<u>Photo Representation Methods to be Compared Slides to be Shown for Each Sample Plot *</u>	<u># Plots Represented</u>
<u>FOREST PLOTS</u>			
Full Plot Representation	8	[a,b,c,d,g,l,m,r] and [a,b,c,d,h,s,n,i]	30
Point Representation A	4	[abcd], [efgh], [ijkl], [mnop], [qrst]	30
Point Representation B	4	[abcd], [g,l,m,r]	30
Individual Slide Representation	1	[a], [b], [c], [d]	30
<u>WOODLAND PLOTS</u>			
Full Point/ Plot Representation	4	[a,b,c,d]	60
Individual Slide Representation	1	[a], [b], [c], [d]	30

* Refer to Figure 1 for slide identification. The [] indicate which slides will be shown together in sequence for a single overall scenic beauty judgment.

most of the Woodland plots, are more sparsely wooded than those areas typically used in earlier studies. Thus, there is the possibility that the extent of views may be greater in many of the slides, and that distant, "vista", elements may be influential in the SBEs obtained. To address this issue (Objective 5) a sample of Forest and Woodland slides will be judged for extent of view, percent of view in sky, background topography and vegetation, etc. Following the procedures of Buhyoff, Wellman and Daniel, 1982, these "vista" features will be coded and entered into regression models as independent variables to assess their contribution to SBEs for the sample plots. These judged variables may be used separately, or together with influential bio/physical variables in scenic beauty models.

Results

The results of all of the above described studies and analyses will be combined into a final report. The advantages and disadvantages of each photo-representation method will be addressed, along with the results of each assessment. The principal focus of the study is on the SBE models, and the potential of using standard Forest Survey inventory information as a basis for estimating the magnitude and geographic distribution of natural scenic resources.

References

- Brown, T. C., and Daniel, T. C. (1984). Modeling forest scenic beauty: concepts and application to Ponderosa pine. (U.S.D.A. Forest Service research paper RM-256). Fort Collins, Colorado: Rocky Mountain Forest and Range Experiment Station.
- Buhyoff, G. J., Wellman, J. D., & Daniel, T. C. (1982). Predicting scenic quality for mountain pinebeetle and western spruce budworm damaged vistas. Forest Science 28: 827-838.
- Daniel, T. C., and Boster, R. S. (1976). Measuring landscapes esthetics: the scenic beauty estimation method. (U.S.D.A. Forest Service research paper RM-167). Fort Collins, Colorado: Rocky Mountain Forest and Range Experiment Station.
- Schroeder, H. W., and Brown, T. C. (1983). Alternative functional forms for an inventory-based landscape perception model. Journal of Leisure Research 15(2):156-163.
- Schroeder, H. W., and Daniel, T. C. (1980). Predicting the scenic quality of forest road corridors. Environment and Behavior 12: 249-366.
- Schroeder, H. W., and Daniel, T. C. (1981). Progress in predicting the perceived scenic beauty of forest landscapes. Forest Science 27(1):71-80.

Instructions for Photo Sample--1984 INT Resources Evaluation Unit

General on camera

- The camera is a Pentax SE-K1000 35 mm SLR with 50 mm lens and internal light meter
- Keep as cool and dust-free as possible
- Set ASA at 64, for using the Kodacolor 36 exposure ASA64 slide film
- Use ^{haze} filter on lens
- Set shutter speed ≥ 30 (i.e., $\leq 1/30$ of second), and ≥ 60 if possible (see below for details)
- Set aperture at a high F-stop if possible (see below for details)

General procedure at a plot

1. Check film counter to make sure sufficient frames exist on roll of film to finish next point (including header card, if applicable). If insufficient, rewind and insert a new roll.
2. At beginning of each roll and at beginning of each location, take picture of the header card containing county, location, point number, date, time of day, and inventory crew identification.
3. From center point (point number 1), take four pictures, one in each of the following directions: 60° , 120° , 240° , and 300° (see figure 1).
4. For the 5-point locations, take four pictures from each satellite point (point numbers 2, 3, 4, and 5) in the cardinal directions, beginning with north, then east, south, and west (figure 1).
5. If you unexpectedly come to the end of a roll of film in the middle of photographing a point, finish the point on a new roll, to photograph the header card indicating that "the following () pictures complete point ()."
6. If you take one picture, or more than one consecutive pictures, which have problems (e.g., shutter pressed accidentally, a person walked in picture) which are therefore not part of the inventory, take a picture of the header card indicating that "the previous () pictures should be ignored."

Taking a picture (except of header card)

1. Focus, and change framing if necessary.
2. Focal length and lighting: To maximize depth of field, pictures should be taken at high end of F-stop scale (8, 11, 16, or 22). Note that higher F-stops require lower shutter speeds for proper lighting. Therefore, for each picture:
 - a. set shutter speed at 120.
 - b. set F-stop to proper lighting using light meter. May have to shorten shutter speed (move camera setting to a higher shutter speed number) if there is too much light, or lengthen shutter speed (to a setting of 60) if F-stop for proper lighting is below 8.
 - c. If light is insufficient with shutter speed at 60 and F-stop at 8, widen the aperture (select lower F-stop setting), going to an F-stop of 2 if necessary. Then, if light is still insufficient, lengthen shutter speed to a setting of 30 and select proper F-stop.
3. Advance film.
4. Stand still and exhale.
5. Have someone shade lens if sun strikes lens directly.
6. Take picture.
7. Note: Take picture in any weather, except where camera could be damaged (e.g., by moisture).

Framing a picture (except of header card)

1. Stand and hold camera at eye level.
2. Aim in proper direction (figure 1).
3. Holding camera perpendicular to body, look through lens. If ground slopes up, tilt head and camera up until the picture looks right; if the ground slopes down, tilt head and camera down until the picture looks right.
4. If objects (e.g., trunks, branches, leaves, etc.) near to camera obstruct the view, move anywhere within a 5-foot radius of the point to avoid the obstruction and begin at step 1 of framing procedure. Have partner hold close up branches out of camera view if necessary.
5. Avoid people, equipment, marking tape, etc. in photo.

Film management

1. Keep film as cool as possible.
2. Avoid dust and direct sunlight when changing film.
3. Send exposed film to developing lab at first opportunity.

Changing (rewinding and loading) film

1. Push in button on bottom of camera (may need to keep pressure on it).
2. Lift arm on rewind knob (don't lift knob).
3. Turn knob clockwise until film releases.
4. Lift rewind knob to open back of camera.
5. Remove new roll of film from plastic canister.
6. Insert exposed film in plastic canister from new roll.
7. With rewind knob up, insert new film in camera, then push down rewind knob.
8. Insert leader and advance film, making sure film is on sprockets. Note that take-up reel rotates clockwise, as seen from top of camera.
9. Close back of camera and turn rewind knob until it gives resistance.
10. Advance film and depress shutter twice (counter will then be set at 0). Make sure rewind knob turns as film is advanced.
11. Insert exposed film with canister in mailer.
12. Drop mailer in mail box, but first write date mailed on record stub and detach stub from mailer.
13. Once a week, send detached record stubs to Tom Brown in addressed envelopes.

Appendix B: FIA DATA FILE FOR SCENIC BEAUTY MODELING

Intermountain Station Forest Inventory and Analysis (FIA) data for the 1984 inventory in western Colorado will be summarized for selected variables into 3 files: (1) plot (i.e., location)-level data for woodland plots; (2) plot-level data for timberland plots, and (3) point-level data for timberland plots. Woodland plots have 1 point (IR30 = 1) while timberland plots have 5 points (IR30 = 5). Each file will contain the same variables and formats, and will contain a maximum of 80 columns per record.

The 1984 FIA data are currently in two files, a timber data file and an understory data file. The former is the large, 677 column per record, file called COLO84. The latter is a small file, containing 19 columns per record, currently in card form. The first 130 variables below come from the timber data file, while the final 12 variables are from the understory data file.

For the records of interest in the timber data file (those with an acceptable TREE HISTORY value), each record in the FIA data refers to a separate tallied tree. Thus, data for variables that refer to the entire plot are repeated for each tree tallied at the plot. The "Unit Record Data File" list indicates whether a variable is specified by plot or by tree. Tree-specific data must be averaged per point or plot (in addition, high and low values across the point or plot are requested for one variable). Where data for plot-specific variables are needed, it can either be read from one record of the plot, or the average across the records can be computed (as it must be for those variables that have tree-specific data).

The following plot-level variables are needed:

	<u>Line</u>	<u>Col</u>	<u>Format</u>
1. STATE (from IR 1, STATE CODE)	1	1-2	I2
2. MAP (from IR2, P.I. MAP NUMBER)	1	3-6	I4
3. COUNTY (from IR9, COUNTY)	1	7-9	I3
4. PLOT (from IR10, LOCATION NUMBER)	1	10-13	I4
5. MONTH (from IR 11, DATE OF SURVEY)	1	14-17	I4
6. CREW (from IR12, CREW NUMBER)	1	18-19	I2
7. LANDUS (from IR16, GROUND (LAND USE)	1	20-21	I2
8. OWNER (from IR18, OWNERSHIP)	1	22-23	I2
9. STAND (from IR20, STAND CLASS)	1	24	I1
10. FORTYP (from IR22, FOREST TYPE)	1	25-26	I2
11. ELEV (from IR25, ELEVATION)	1	27-29	I3
12. ASPECT (from IR26, ASPECT/SLOPE/ CURVATURE CLASS)	1	30	I1
13. SLOPE (from IR26, ASPECT/SLOPE/ CURVATURE CLASS)	1	31-32	I2
14. CURVE (from IR26, ASPECT/SLOPE/ CURVATURE CLASS)	1	33	I1
15. PHYSIO (from IR27, PHYSIOGRAPHIC CLASS)	1	34-35	I2
16. PAST (from IR32, PAST TREATMENT)	1	36-38	I3
17. CRNCOV (from IR46, PERCENT LIVE TREE CROWN COVER, TOTAL)	1	39-40	I2
18. SI BASE (from 5th column of IR 124, SITE INDEX)	1	41	I1
19. SI (from 6th, 7th, and 8th columns of IR124, SITE INDEX)	1	42-44	I3

	<u>Line</u>	<u>Col</u>	<u>Format</u>
20. AGE (from IR127, STAND AGE, converted to years based on class midpoints)	1	45-48	I4
21. HABITAT	1	49-51	I3
a. for woodland plots, from IR28, PRIMARY HABITAT TYPE			
b. for timberland plots, from IR28, PRIMARY HABITAT TYPE			
c. for timberland points, from IR61, SPECIES, for records with IR59, TREE HISTORY, = 8, or if no 8, 9			

The following point-level variables are needed:

22. POINT NUMBER (IR55)	1	52-53	I2
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The following tree-level variables are needed:

23. DIST (mean of IR58, DISTANCE, for records with IR59, TREE HISTORY = 1, 4, or 6)	1	54-55	I2
24. MINDIS (minimum of IR58 for records with IR59 = 1, 4, or 6)	1	56-57	I2
25. MAXDIS (maximum of IR58 for records with IR59 = 1, 4, or 6)	1	58-59	I2

26-113. Number of live trees per acre by species group and size class. The number of trees is found in IR111, NUMBER OF TREES PER ACRE, for the records with IR59 = 1, and IR62, DBH/DRC/SEEDLING COUNT, for records with IR59 = 3 or IR59 = 7. D (diameter) is given by IR62 for timberland and IR89 for woodland. D indicates dbh for timberland and DRC (diameter root crown) for woodland. The species groups are:

25a. PINO (from IR3, P.I. POINT NUMBER) 1 60-63 I4
 25b. CROCON2 (from IR24, PERCENT CROWN COVER) 1 64 I1
listed as a code, not actual percent

<u>Species group</u> <u>and name</u>	<u>Species code</u> <u>(from IR61)</u>	<u>Line</u>	<u>Col</u>	<u>Format</u>
a. SP spruce-fir	15-20, 93-96, 202	2		8F9.3
b. Ju juniper	50-69	3		8F9.3
c. PY pinyon pine	106	4		8F9.3
d. PP ponderosa pine	122, 136, and 137	5		8F9.3
e. AS aspen	746	6		8F9.3
f. GO gambel oak	814	7		8F9.3
g. CO cottonwood, poplar sycamore	730-745, 747-749	8		8F9.3
h. OT other	all others	9		8F9.3

NOTE: no lodgepole pine (species code 108), other pine (codes 101-105, 109-119, 133-135) or brush (codes 300, 960, 475-479) was found.

The following procedure differs for timberland and woodland depending on D = diameter.

- a. SEED (seedlings) 1-9
- 1) timberland: sum IR111 for
records with IR59 = 1 and
 $D \leq 1.0$, then add IR111 for
any IR59 = 7 records
 - 2) woodland: sum IR111 for
records with IR59 = 7

	<u>Line</u>	<u>Col</u>	<u>Format</u>
b. SAP (saplings)		10-18	
1) timberland: sum IR111 for records with IR59 = 1 and D > 1.0 and $\leq$ 4.9, then add IR111 for any IR59 = 3 records			
2) woodland: sum IR111 for records with IR59 = 1 and IR89 > 1.0 and $\leq$ 4.9, then add IR111 for any IR59 = 3 records			
c. 59: sum IR111 for records with IR59 = 1 and D $\geq$ 5.0 and $\leq$ 8.9		19-27	
d. 912: sum IR111 for records with IR59 = 1 and D $\geq$ 9.0 and $\leq$ 11.9		28-36	
e. 1216 : sum IR111 for records with IR59 = 1 and D $\geq$ 12.0 and $\leq$ 15.9		37-45	
f. 1620: sum IR111 for records with IR59 = 1 and D $\geq$ 16.0 and $\leq$ 19.9		46-54	
g. 2024: sum IR111 for records with IR59 = 1 and D $\geq$ 20.0 and $\leq$ 23.9		55-63	
h. 24PL: sum IR111 for records with IR59 = 1 and D $\geq$ 24.0		64-72	

	<u>Line</u>	<u>Col</u>	<u>Format</u>
114-121. DT (dead trees by size class; take D from IR89 for woodland and IR62 timberland)	10		8F9.3
a. SEED: sum IR111 for records with IR59 = 4 ^{or} 6 and D ≤ 1.0		1-9	
b. SAP: sum IR111 for records with IR59 and ^{or} 46 _^ and D > 1.0 and ≤ 4.9		10-18	
c. 59: sum IR111 for records with IR59 and ^{or} 46 _^ and D ≥ 5.0 and ≤ 0.9		19-27	
d. 912: sum IR111 for records with IR59 and ^{or} 46 _^ and D ≥ 9.0 and ≤ 11.9		28-36	
e. 1216: sum IR111 for records with IR59 and ^{or} 46 _^ D ≥ 12.0 and ≤ 15.9		37-45	
f. 1620: sum IR111 for records with IR59 = and ^{or} 46 _^ and D ≥ 16.0 and ≤ 19.9		46-54	
g. 2024: sum IR111 for records with IR59 = and ^{or} 46 _^ and D ≥ 20.0 and ≤ 23.9		55-63	
h. 24PL: sum IR111 for records with IR59 = and ^{or} 46 _^ and D ≥ 24.0		64-72	
122. HEIGHT (mean of IR63, HEIGHT TO NEAREST FOOT, for records with IR59 = 1, 4, or 6)	11	1-4	F4.0
123. MAXCRN (mean of IR83 for records with IR59 = 1)	11	5-7	F3.0
124. MINCRN (mean of IR84 for records with IR59 = 1)	11	8-10	F3.0
125. BA (sum or IR112 for records with IR59 = 1, 4, and 6)	11	11-20	¹⁰ F ~~8~~ .3
126. DTCUFT (sum of IR152 , NET CUFT VOL.-DEADWOOD, for records of IR59 = 1, 4, or 6)	11	21-30	¹⁰ F ~~9~~ .3

	<u>Line</u>	<u>Col</u>	<u>Format</u>
127. TOCUFT (sum of IR155, NET CUFT VOL.-TOTAL WOOD FIBER, for records with IR59 = 1, 4, or 6)	11	31-40	¹⁰ ~~F8~~ .3
128. BOTCUFT (sum of IR161, GROSS CF VOL. TO A MERCHANTABLE TOP, for records with IR59 = 1, 4, or 6)	11	41-50	¹⁰ ~~F8~~ .3
129. BFINT (sum of IR 165, GROSS BF VOL. SCRIBNER RULE, for records with IR59 = 1, 4, or 6)	11	51-60	¹⁰ ~~F8~~ .3
130. GROWTH (sum of IR166, ANNUAL NET GROWTH-NETCF TO MER TOP, for records with IR 59 = 1, 4, or 6)	11	61-70	¹⁰ ~~F8~~ .3

The understory data file lists point-level data.

It contains the following variables:

<u>Column</u>	<u>Variable</u>
1-3	COUNTY
4-6	PLOT (location)
7	POINT
8-19	twelve herbage canopy variables in 11 format.

COUNTY, PLOT, AND POINT are used to match the herbage canopy data with the tree data (variable numbers 3, 4, and 22, respectively). The 12 canopy variables give canopy percent, converted from the original class codes by taking class midpoints:

131. HCGR1	(col 19)	herbage canopy of grasses in	12	1-3	3(4I3,1X)
		lowest tier			
132. HCF01	(col 18)	herbage canopy of forbs in	12	4-6	
		lowest tier			
133. HCSH1	(col 17)	herbage canopy of shrubs in	12	7-9	
		lowest tier			
134. HCTR1	(col 16)	herbage canopy of trees in	12	10-12	
		lowest tier			

			<u>Line</u>	<u>Col</u>	<u>Format</u>
135. HCGR2	(col 15)	herbage canopy of grasses in middle tier	12	14-16	
136. HCF02	(col 14)		12	17-19	
137. HCSH2	(col 13)		12	20-22	
138. GCTR2	(col 12)		12	23-25	
139. HCGR3	(col 11)	herbage canopy of grasses in highest tier	12	27-29	
140. HCF03	(col 10)		12	30-32	
141. HCSH3	(col 9)		12	33-35	
142. HCTR3	(col 8)		12	36-38	

These data, combined with associated SBEs, are maintained on computer tape, and are available for future use.